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MULTICHANNEL FIELD-EFFECT SEMICONDUCTOR DEVICE

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ABSTRACT OF THE DISCLOSURE

An improvement to multichannel field-effect semi-conductor devices of the type comprising a substrate wafter of semiconductor material of a given type of conductivity, source and drain regions on the parallel major faces of the wafer, a diffused internal gate of the opposite type of conductivity, said gate including a perforated region defining conductive channels and a solid region, and a diffused superficial gate contact region superimposed on said internal solid region and in ohmic contact therewith. The improvement consists in providing as a part of said internal gate strip regions originating in the solid region and, as a part of said superficial gate contact region, superficial diffused regions superimposed on said strip regions.

This invention relates to improvements in field-effect semiconductor devices for use in amplifiers, oscillators or electronic switches having a drain electrode, a source electrode and at least one gate electrode, the latter being also called "control electrode" or "grid electrode." More precisely, the invention relates to those of such devices which include a wafer of semiconducting material of a given type of conductivity, a drain zone and a source zone in said wafe respectively adjacent to one and the other of the parallel major surfaces thereof, and a multichannel connection between said zones consisting of a number of conductive channels passing through at least one gate or "grid body" made of the same semiconducting material but having the opposite type of conductivity to said given type of conductivity. These conductive channels are connected together at their extremities by layers of said semiconducting material having said given type of conductivity.

Devices of this kind are commonly called "gridistors"; they may be provided with one or two control grids. Although in the following the sole case of single-grid devices (solid state triodes) will be considered, it must be understood that the invention also applies to devices with two control grids (solid state tetrodes).

A device of the same kind has been described, for instance, in the U.S. Patent Ser. No. 3,274,461, issued Sept. 20, 1966.

It is known that the source and drain electrode contacts in such a structure are ohmic in the case of unipolar gridistors (with majority carriers) designed for low intensity current operation at high or very high freqencies, and are rectifying (with minority and majority carriers) in the case of bipolar gridistors designed for high intensitivity current opeation. These contacts are located on the already mentioned parallel major surfaces of the semiconductive wafer forming the gridistors.

A control electrode contact, always ohmic, with the grid body must also be provided. It is formed inside the wafer by a diffusion and welding process, possibly after chemical or electrochemical etching of the wafer to uncover a suitable portion of the grid body.

Once the grid contact has been obtained, it is necessary that the resistance in the grid body between the contact point and the most remote conductor channel, which re-

sistance hinders operation of the gridistor, be sufficiently low for the field effect to be applied almost simultaneously and without any appriciable delay to all the channels in the structure. Actually, for unipolar gridistors, the high risitance of the grid body and the capacitance of the structure for the signal applied between the grid and one of the other electrodes lead to a proportionally high charging time constant except in the case where if the dimensions of the structure are very small; this is likely to entail a considerable reduction in the high frequency performance of the device. In practice, it is desirable that this time constant be limited to the order of magnitude of 10^{-10} second.

In the case of bipolar gridistors, whose dimensions are necessarily relatively large, owing to the higher power to be controlled, the excessive resistance of the grid could hinder the rapid elimination of the carrier plasma from the channels, which elimination is absolutely necessary for the development of space charges therein; this elimination corresponds, in fact, to a grid current peak of very short duration (generally of the order of a fraction of a microsecond), but of quite considerable amplitude (of the order of about ten to several tens of amperes) which must be supplied with a relatively low grid control voltage (of the order of approximately ten or several tens of volts at most).

Furthermore, to obtain the best possible advantages from the structure of a gridistor, it is necessary that the part of the area allocated to the channels in the total area of the grid be as large as possible, therefore that the spacing between these channels be as small as possible. It follows therefrom that the specific resistance of the grid body will be necessarily and relatively high, even with the highest possible impurity concentration obtainable practically.

An apparent incompatibility will thus be noticed between the two fundamental conditions recalled hereabove: very low grid resistance large number of channels, with high channel density. The purpose of this invention is to remove this incompatibility.

The first object of the invention is to form structures where the density of chanels as well as the proportion of the total grid area taken up by them are raised to a practically obtainable maximum and where, nevertheless, the grid is substantially equipotential in relation to the potential of its feed point.

According to the invention, contact to the inner grid is made from the surface of the wafer forming the semiconductor device by additional grid contact diffusion, not only throughout the length of a frame or in a central zone of the device, but also along strips or fingers, issuing from the frame and running inwards or from the central zone outwards, wherefrom, it results that the distance between any conductor channel and that part of the grid which is at the surface of the wafer is below a predetermined limit.

Efficient operation of an equipotential grid requires a satisfactory contact between the superficial part of the grid to which the grid electrode is soldered and the internal body of the grid; otherwise the grid resistance could be increased by a contact resistance higher than said grid resistance by one order of magnitude or even several orders of magnitude.

In planar gridistor construction where the grid contact is obtained by causing diffusion from a contact zone into the grid body, a strictly limited time is available to make this contact. As a matter of fact, it must be kept in mind that the structure of the grid originally formed by diffusion undergoes three extensions, one during epitaxial growth, the second during formation of the silica mask designed for forming the frame for making internal grid